FINAL TECHNICAL REPORT

MODELING OF CHROMOSPHERIC STRUCTURE BASED ON MILLIMETER AND SUBMILLIMETER LIMB BRIGHTNESS PROFILES

NASA GRANT NUMBER:	**NAGW 723**
PRINCIPAL INVESTIGATOR:	**Charles A. Lindsey**
CO-INVESTIGATORS:	**John T. Jefferies** **Thomas L. Roellig**
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ENDING DATE:	**September 30, 1991**

This is the final technical report on NASA grant NAGW 723, entitled "Modeling of Chromospheric Structure Based on Millimeter and Submillimeter Limb Brightness Profiles." The grant was originally scheduled to run for one year, from April 1, 1989 to March 31, 1990. In February, 1990, we requested and were given a no-cost extension of 12 months, to March 31, 1991. We subsequently extended the program another six months, ending the project on September 30, 1991, after which I left the University of Hawaii to work at the National Solar Observatory in Tucson, Arizona.

The purpose of the project was to use new observations of the solar limb occultation in submillimeter radiation to model the physical conditions in chromospheric structure, particularly spicules. The observations were made under an earlier NASA grant (likewise designated NAGW 723) from the Kuiper Airborne Observatory. We observed the occultation of the solar limb by the lunar limb in the total solar eclipse of March 18, 1988, as it passed over the Pacific Ocean north of Guam.

The project we are reporting on was essentially a continuation of our program to measure the limb brightness profile of the Sun from 30 to 200 μm, to check models of the low chromosphere and temperature minimum region. This was based on observations made from the Kuiper Observatory of the total solar eclipse of July 31, 1981 as it passed over the Pacific Ocean northeast of Japan. The new observations added limb brightness profiles at 360 and 670 μm to our database.

The particular tasks undertaken in this project were

(1) reduction of the occultation data to limb brightness profiles at the new wavelengths observed, and

(2) modeling of chromospheric structure to fit the limb brightness profiles.

Both of these tasks have been completed and the results are published (Roellig *et al.* 1991). A copy of this work is enclosed.

The techniques used in reduction of the observations to limb brightness profiles are those developed by Lindsey *et al.* (1986). The basic modeling methods used were those described by Lindsey (1987) and Braun and Lindsey (1987). In fact, the new 360 and

670 μm limb brightness profiles obtained in the 1988 observations were used to adjust the spicule model of Braun and Lindsey (1987) and have resulted in substantially lower densities at higher elevations than their model. However, the new limb brightness profiles do add confirmation to the considerably lower temperatures in the spicular medium than earlier models (e.g. Beckers 1972).

I think I should mention that the results of this work were one of real the highlights Alan Clark's excellent review of solar submillimeter eclipse work in IAU Symposium 154 on Infrared Solar Physics, the first IAU conference, recently held, on this increasingly important field of research. Clark pioneered the limb-occultation technique of measuring the solar limb brightness profile in submillimeter radiation for the purpose of chromospheric modeling in the seventies. His review will appear in the Symposium Proceedings, now being prepared.

This project ends a considerable effort to obtain high-resolution limb brightness profiles over a broad range of wavelengths using airborne eclipse observations and to use them for modeling of the solar chromosphere independent of considerations related to gravitational-hydrostatic equilibrium, a difficult and unreliable assumption that has plagued past chromospheric models. However, the modeling methods we have developed are being greatly improved, most recently with the work of Jefferies and Lindsey (1988) and Lindsey and Jefferies (1990), and much more detailed models using the Kuiper Airborne observations are planned. Moreover, the occultation methods developed using the Kuiper Observatory were recently used at the James Clerk Maxwell Telescope when a total solar eclipse passed over Mauna Kea on July 11, 1991, to give us by far the best observations of this sort yet made, in 1.3 mm radiation (Lindsey et al. 1992, preprint also enclosed). The new, highly structured chromospheric models we are planning will be based on the Kuiper Airborne observations together with the new millimeter observations.

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Roellig, T. L., Becklin, E. E., Jefferies, J. T., Kopp, G. A., Lindsey, C., Orrall, F. Q., and Werner, M. W. 1991, *Ap. J.* **381**, 288.

PUBLICATION UNDER THIS GRANT

(from April 1, 1989)

Roellig, T. L., Becklin, E. E., Jefferies, J. T., Kopp, G. A., Lindsey, C., Orrall, F. Q., and Werner, M. W. 1991, "Submillimeter Solar Limb Profiles Determined from Observations of the Total Solar Eclipse of 1988 March 18," *Ap. J.* **381**, 288.

This publication describes the following aspects of the program:

(1) the limb-occultation observations made in the 1989 March 18 eclipse in radiation ranging from 30 to 670 μm in wavelength,

(2) the analysis of the data to determine the solar limb brightness profiles, particularly at the longer wavelengths, 360 and 670 μm, and

(3) the use of the new limb brightness profiles to revise and adjust models of temperatures and densities in chromospheric spicules.